Shared Display Wall Based Collaboration Environment in the Control Room of the DIII-D National Fusion Facility

Presented by Gheni Abla

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DIII-D
NATIONAL FUSION FACILITY

FusionGRID
www.fusiongrid.org

Acknowledgments

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- **The National Fusion Collaboratory Project Team**
  - Members: ANL, GA, LBL, MIT, PPPL, PCS, Utah
  - DOE Office of Advanced Scientific Computing Research

Presentation's key points

- **Fusion energy research experiments are time critical team effort**
  - 20-50 people participate in each experiment
  - Intensive 20-30 minute data analysis & decision cycle
  - Data and analysis process and codes becoming complex too
  - Worldwide effort leading to ITER

- **US DIII-D National Fusion Facility is using many collaboration tools**
  - A variety of hardware and software collaboration tools in use

- **Large Format Shared Display Wall System is being used**
  - Displays real-time information about experiment and group activity
  - Enables data analysis result sharing among researchers
  - Facilitates large screen space for video conferencing tools

- **Shared Display Wall deployment is success and more work needed**

Fusion research seeks deployment of environmentally and economically attractive power plant
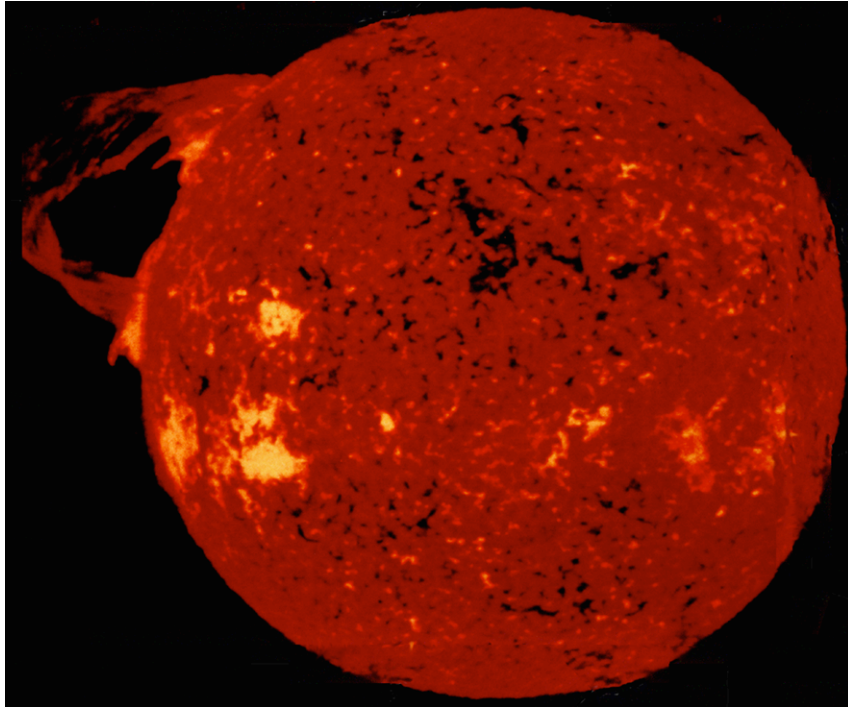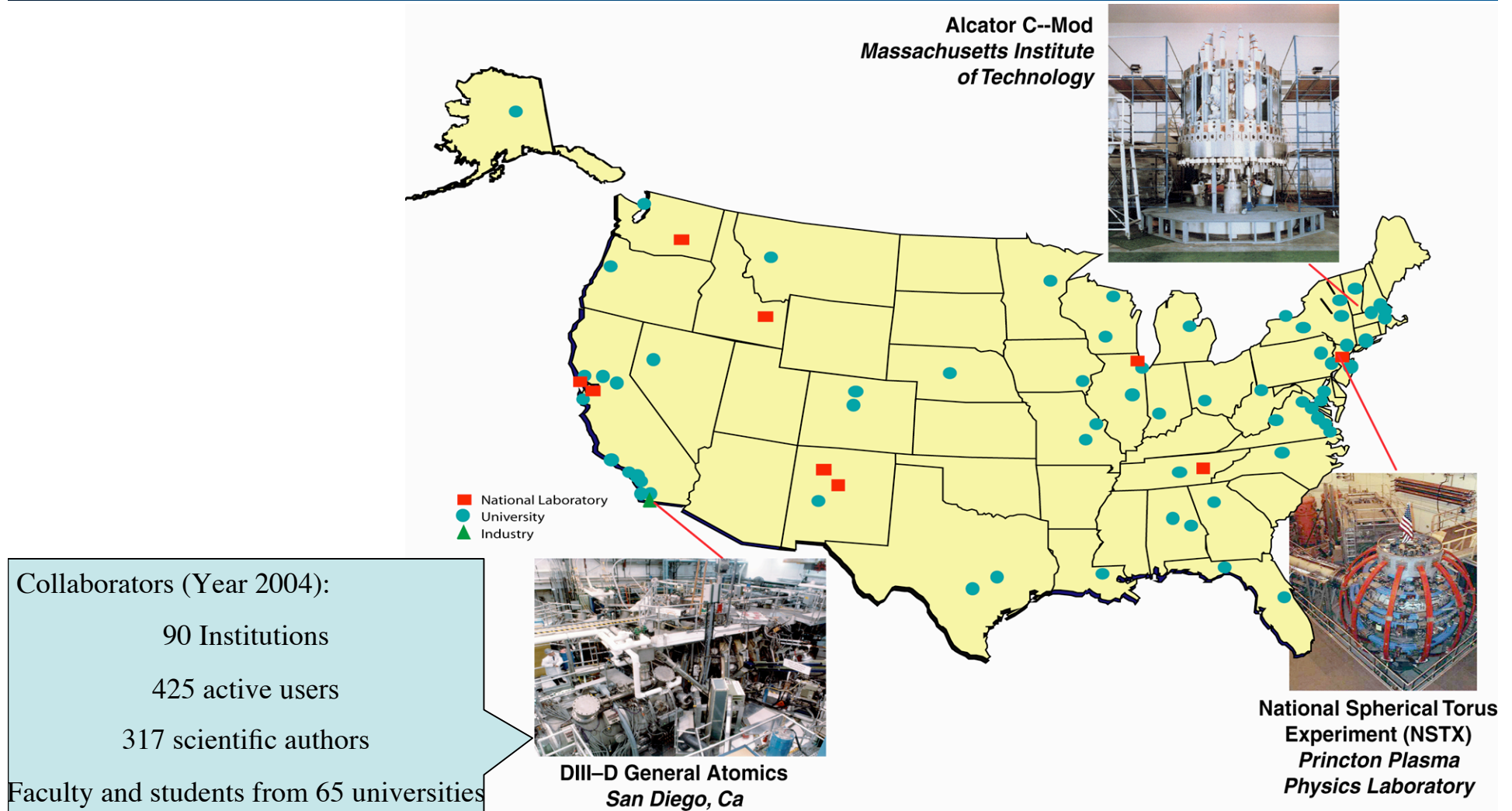

- **Fusion: combining two light atoms into one atom**
  - A nuclear reaction
  - Energy released
- **A very hot reaction: plasma**
- **Fueled by Hydrogen**
- **High energy density**
  - Pickup truck fusion fuel = 21,000 railcars of coal

Fusion is the energy source of sun

Three large U.S experimental facilities and a vibrant theoretical community

Alcator C--Mod
Massachusetts Institute of Technology

National Spherical Torus Experiment (NSTX)
Princton Plasma Physics Laboratory

DIII–D General Atomics
San Diego, Ca

■ National Laboratory
● University
▲ Industry

Collaborators (Year 2004):

90 Institutions

425 active users

317 scientific authors

Faculty and students from 65 universities

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Current trends of fusion research

- **Fusion experiments growing in size and complexity**
  - Number of diagnostics constantly increasing
  - Acquired data is getting larger
  - Data analysis involving a larger group of people

- **Number of fusion facilities decreasing**
  - ITER- the next generation fusion experiment device will be built in France.
  - Long term relocation of US Fusion program is not reasonable.
  - Scientists need to work remotely
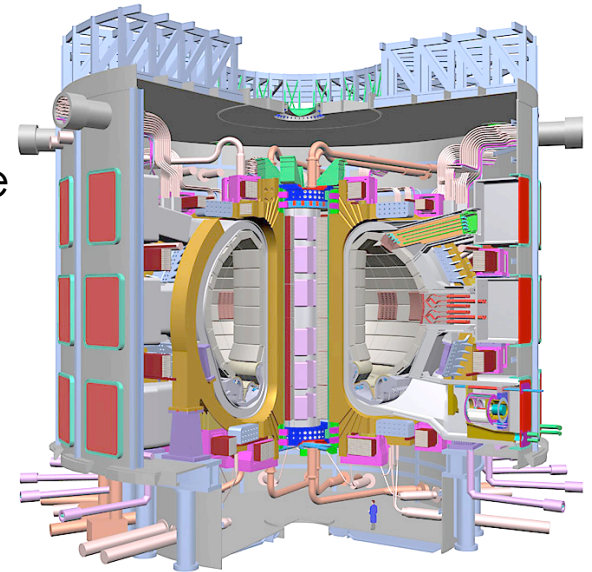
Fusion experiments are time critical operations

- **Fusion experiments consist of a series of pulses, or "shots"**

  – A "shot" is when you turn on the device for a few seconds

  – Take a shot, analyze results, plan next shot, set new device parameters, take next shot…

  – Repeated in every ~20 minutes time
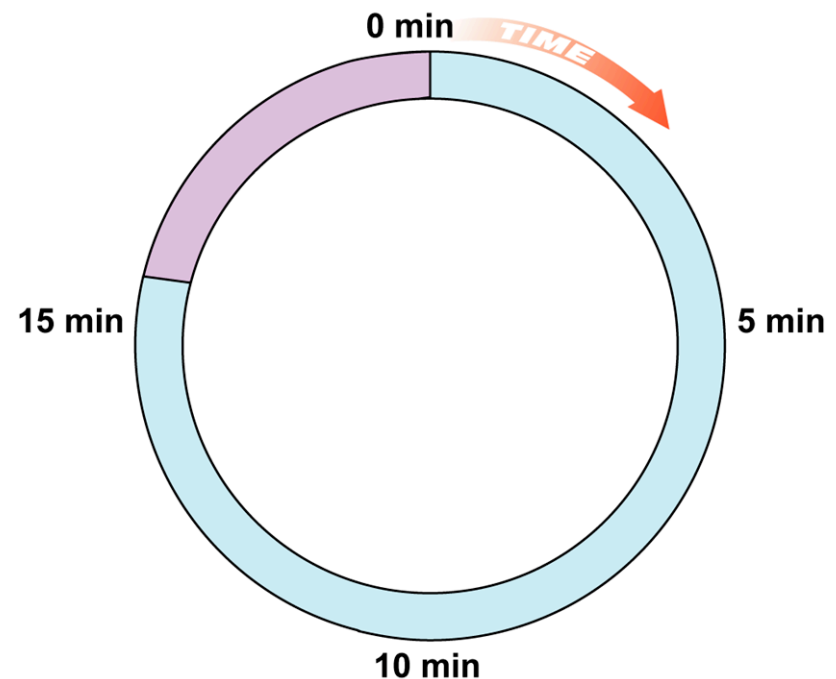
Both local and remote collaborations are critical for successful experiment

- **Experiment control room is complex environment**
  - 20-50 people work towards common goal
  - Team consists of scientists, engineers, technicians, computer scientists
  - Group-activity awareness and collaboration are critical

- **Experiment team also includes remote participants**
  - There are only several fusion experimental devices worldwide
  - Scientists are geographically dispersed
  - Need to access experimental data and participate discussions
  - Collaboration between remote parties also important

Various tools deployed to support fusion research collaborations

- **U.S. National Fusion Collaboratory (NFC) project is building advanced collaborative environment for fusion research**
  - Grid-based computation and collaboration services for experiment & simulation
    - Security
    - Visualization
    - Team collaboration within the control room
    - Remote participation

National Fusion Collaboratory

- **NFC deployed software tools to support control room collaborations**
  - Secure Data Management System & Remote computing
  - Access Grid
  - Instant Messaging
  - Large Format Shared Display Wall System

Shared display walls enhance the collaboration within the control room

- **Shared display has high pixel resolution**
  - Can display multiple visual information that normally doesn't fit in a normal computer screen
  - Capable of presenting multiple aspects of experimental activity

- **Shared display provides large visual space**
  - Presented information visible for all team members at control room

- **Challenge is in software development that matches the need of control room**
  - "what to display"
  - "how to display"

Shared display walls installed at fusion control rooms

NSTX

DIII-D

C-Mod

Shared display wall deployment at DIII-D control room

- **150-inch (3840 X 1024 pixel) large display**

- **Deployment is two step process**
  - Identify experiment related critical info that is common interest of majority team members

  - Develop new tools or customize existing tools for the shared display environment

- **Deployed shared display wall software tools**
  - Visualization tools that provide up-to-date information about experiment status
  - Data analysis results sharing tools that enable researchers move the information from desktop screen to large format shared display
  - Remote participation and video conferencing tools

Visualization tools for experiment status update

- **Provide real-time info about experiment status and group activity**

- **Tool 1 : Plasma shape movie player**

  – based on time-variable data

  – automatically generates plasma shape
     animation of the newest pulse

  – data update triggered by MDSplus events

Visualization tools for experiment status update (2)

- **Tool 2: Electronic log ticker application**
  - Displays pulse information and experiment comments as a scrolling text
  - Data is read from relational data base
  - Information update is triggered by MDSplus events

240parIA CIII (465 nm)   8x 2 ms R5/8.6 GA = 1.0 yes/no Comments: Tape time 11:24 good data
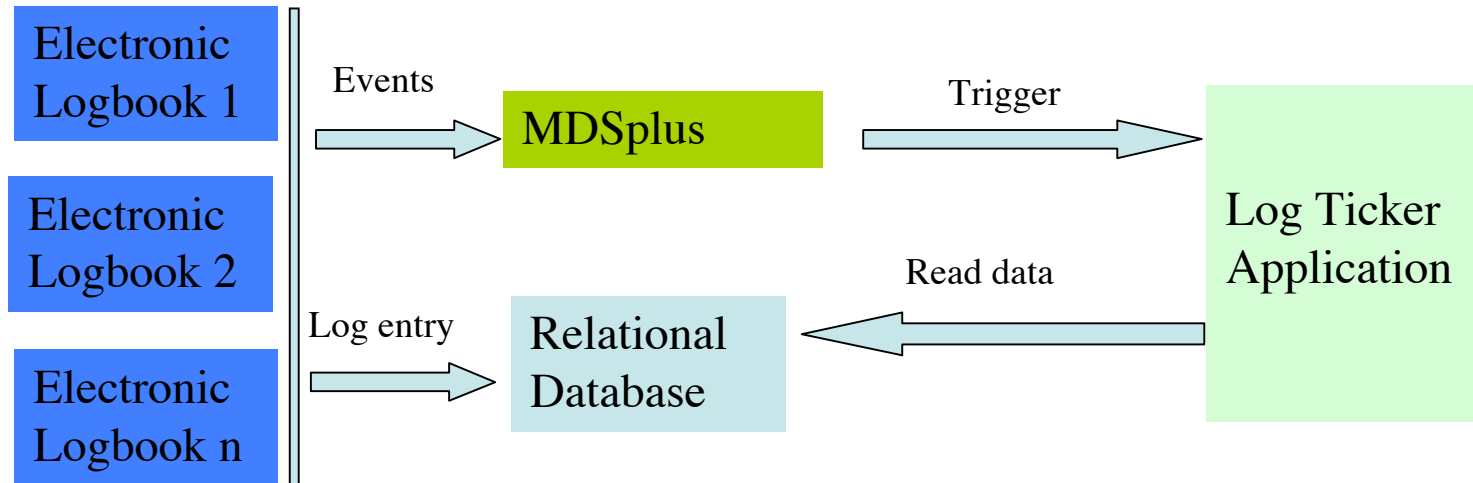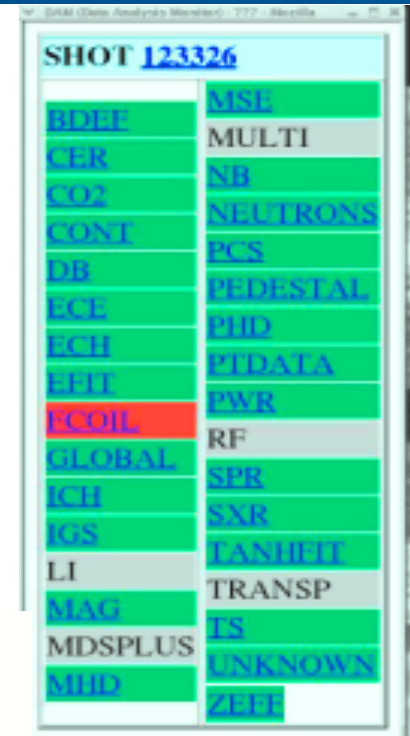
- **Tool 3: Data Analysis Monitor (DAM) status reporter**
  - Analyzes between-pulse data analysis status on real time
  - Generates detailed status report
  - The shared display wall version of the report organized by large categories. Information is color coded:

Grey In progress   **Green** Ok   **Red** Error
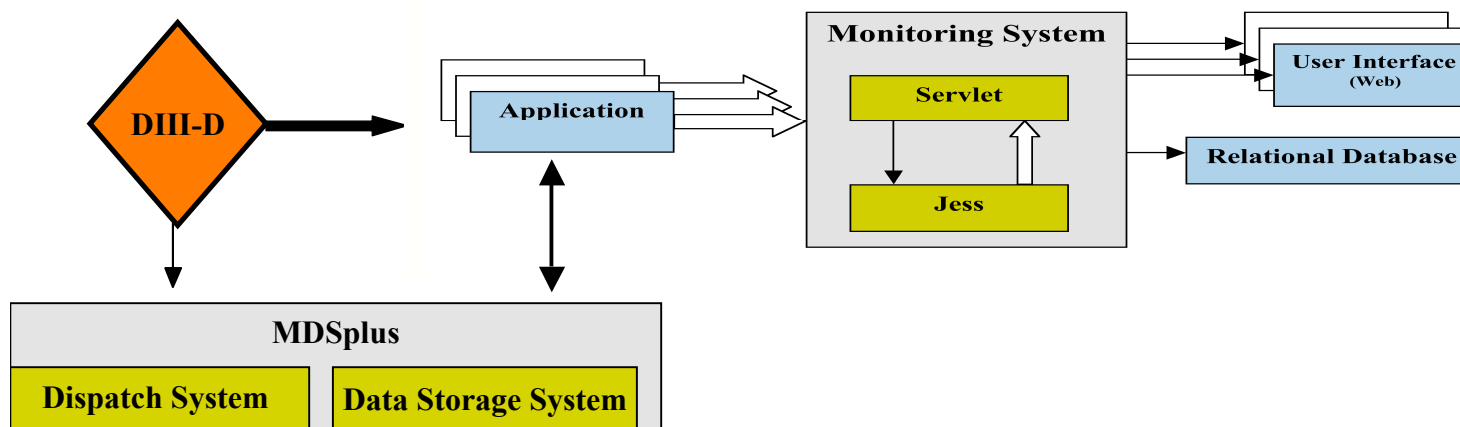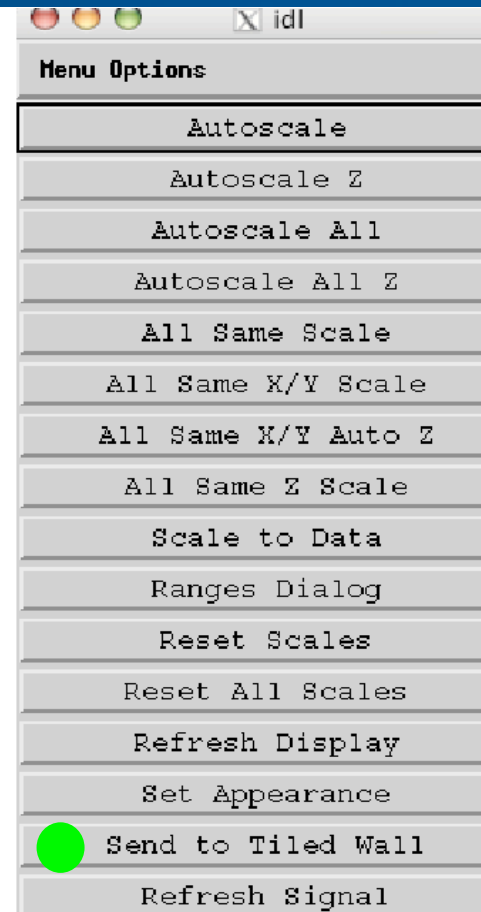
Data analysis results sharing system

- **Captures the visualization window on user's screen as an image and displays on shared display wall**

  - Integrated into IDL based visualization library-GAPlotObj as a menu item
  - Snapshot of visualization window can be sent by choosing the "Send to Tiled Wall" menu item
  - Works with standard data analysis tools based GAPlotObj visualization-plotting library

  - Also integrated into "Toolbar" application (TCL/Tk)
  - Captures a user specified region on the user's desktop screen & displays it on the shared display
 - Shared image on the display wall can be saved by other users

VNC-based data analysis sharing system

- Allows users to share dynamic content from their workstation display.

- Based on a modified VNC protocol which shares individual windows rather than the entire desktop.

- Shared windows can be positioned independent of one-another on the shared display.
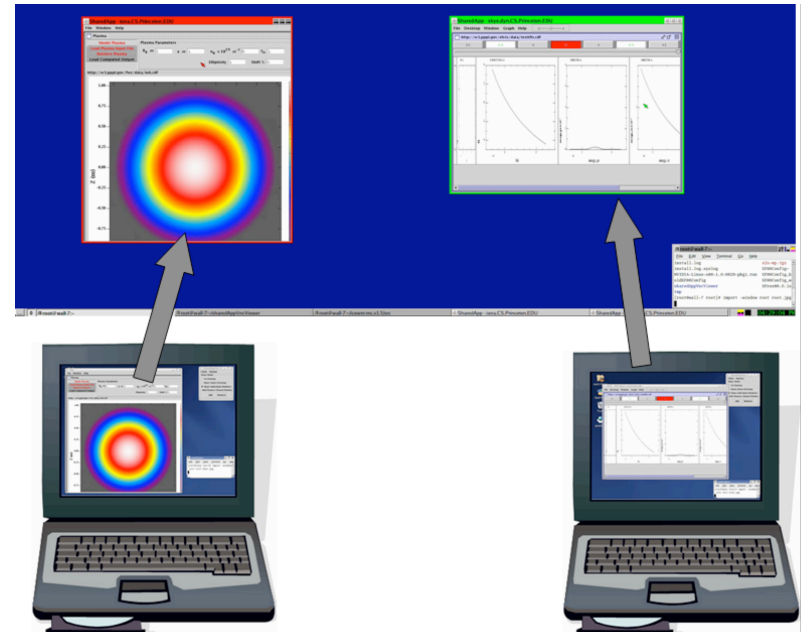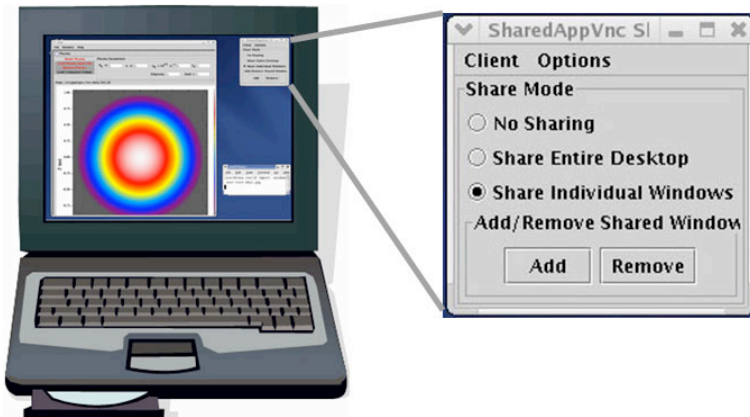
# Simultaneous user interaction on the shared display

- **Each user is assigned their own uniquely colored cursor.**

- **When user drags mouse off the edge of his workstation screen, it appears on the shared display.**

- **Users can simultaneously give mouse and keyboard input to applications on the shared display.**

- **Multi-cursor capability is implemented within a modified window manager by time-slicing the system cursor.**
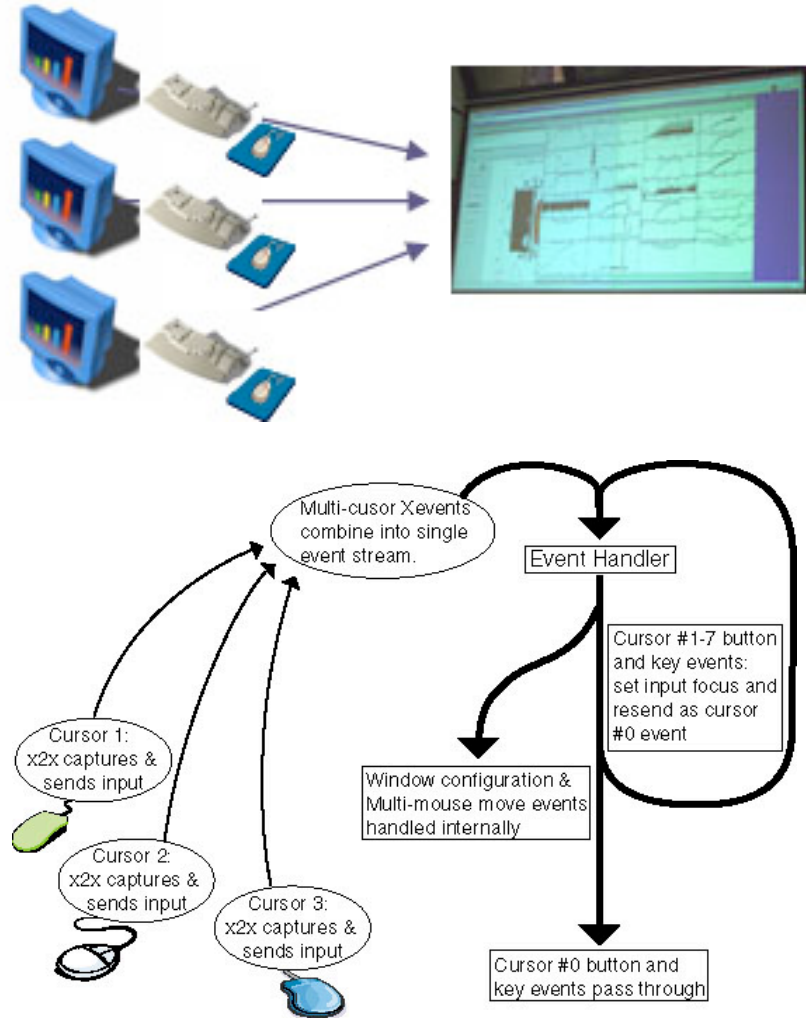
Using shared display wall system for remote participation

- **Video streams of Access Grid and VRVS from remote sites displayed**

- **Life sized video of remote participant gave a realistic impression**
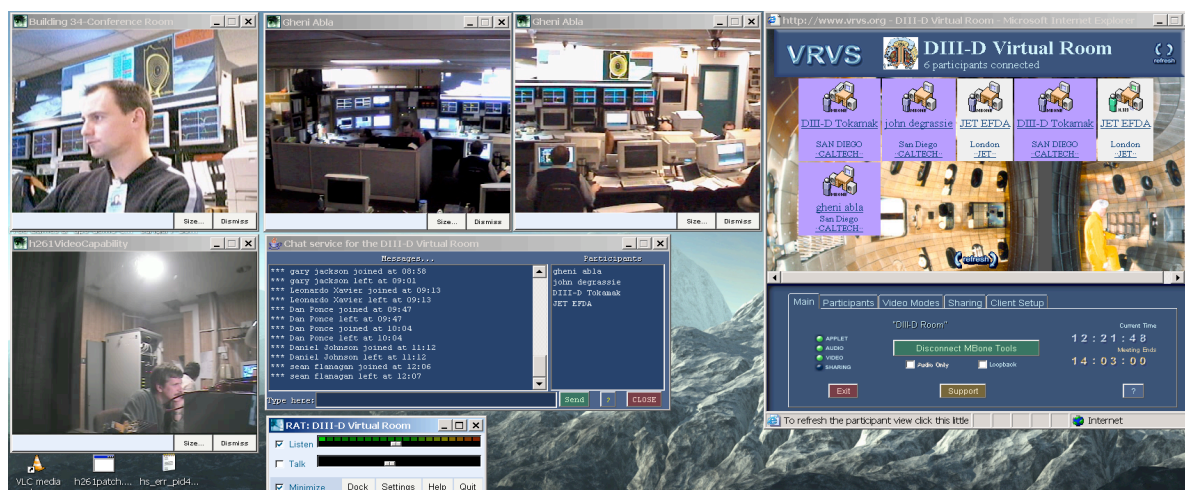
- **Controllable camera is for monitoring the shared display and control room**
  - Remote participants can control (Pan/Tilt/Zoom) through the web
  - Example: Remote scientist in UK shared his screen snapshot image to the wall and then used camera to make sure his image was displayed correctly

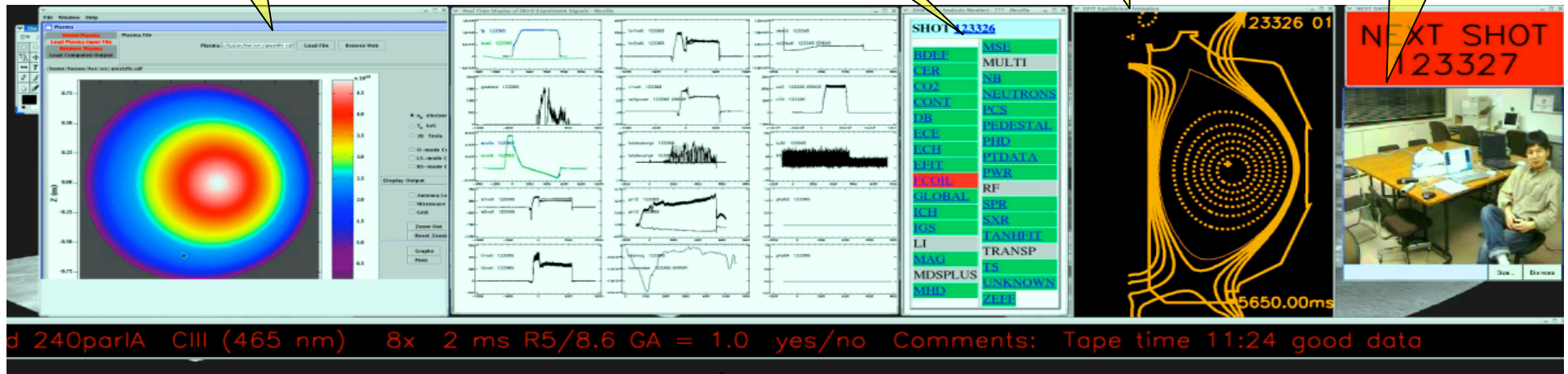# A screen capture of the DIII-D shared display wall

Shared data analysis results

Real time signal plots

DAM report

Plasma shape movie player

Video of remote collaborator

Electronic log ticker application

Learned lessons

- GUI based desktop apps are not necessarily usable on shared display: GUI layout, color, font, cursor needs to be customized

- Collaboration tools need to be easy to use and should not request extra effort

- Not all of the tools from computer science labs directly work for control room environment.

- Location and size of the shared display and lighting in the control need carefully planned.

Results and Future Work

- **Shared display wall has been utilized during the last experiment campaign**
  - Public presentation space for experiment status and group activity
  - Large "white board" space for information sharing
  - Large screen for displaying video of remote participant
  - Deployment has been an iterative process

- **Final results have been well received by the experimental team**

- **More work needs to be done in the next step**
  - Increase the usability
  - Integrate with other new collaboration technologies.
    - E.g, Instant Messaging, a service of Access Grid
  - Web-based streaming to remote participants
  - More flexible controlling mechanism